Heating of pacemaker leads during magnetic resonance imaging: reply

Luechinger, R

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Heating of pacemaker leads during magnetic resonance imaging

Is MRI contraindicated in PM-patients? In their carefully performed study, Luechinger *et al.*[1] convincingly show the possible heating of pacemaker leads by measuring heating at the lead tip together with the pacing parameters. Heating, comparable with *in vitro* data, occurred in the presence of blood flow. Therefore, protection by the cooling effect of myocardial blood flow in any *in vivo* or clinical setting is small and must no longer be overestimated.

They speculate about the clinical significance and state that there is a lack of follow-up data with respect to significant threshold changes. Our follow-up data showed that battery current and impedance only tended to increase. The calculated rest of function time did not change nor was any significant threshold alteration with the need to modify programmed data observed.[2]

The heating problem may be even more pronounced in the clinical setting. The chest anatomy of swine, even if weighing 60–65 kg, does not resemble that in humans. The difference in radius of the semicircle lead configuration in the coronal plane may lead to heating effects of greater extent in humans. Heating is considered to be especially problematic when objects are configured in a loop or coil, as conducting loops are known to provide a high current density in low impedance, metallic, conductive materials.[3]

It is up to the reader to decide whether it is beside the point to present an editorial comment in an animal study paper that could be understood as a recommendation for clinicians planning to perform MRI scans in pacemaker patients. In a clinical setting, our recommendation is different. If the referring physician, the radiologist, and the cardiologist agree that MRI is an urgent diagnostic necessity without an acceptable imaging alternative in a patient with cardiac pacemaker, certain requirements have to be met. Written informed consent of the patient is needed. To reduce the risk of thermal injury during MRI, RF-exposure and sequence time have to be minimized. Like monitoring of systemic haemodynamics and cardiac rhythm with MRI compatible devices, cardiological standby for online analysis of cardiac rhythm and standby for immediate cardiopulmonary resuscitation belong to the minimal precautions. A complete pacemaker check including interrogation, evaluation of intrinsic rhythm, sensing thresholds, stimulation thresholds, lead impedance, and battery voltage is mandatory before and immediately after MRI. Additional assessments, i.e. 4 weeks following MRI, are recommended.

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We appreciate Dr Vahlhaus' interest in our paper.[1] We agree that heating at the lead tip–myocardium interface may not significantly decrease due to the cooling effect. However, this is only valid for the chronically implanted leads. In the acute setting, scar formation is not prominent and the cooling effects may be more pronounced. In addition, in our study, we did not intend to make a direct comparison between the *in vitro* and *in vivo* settings, as lead configurations and positions were not identical.

We absolutely agree with Dr Vahlhaus' comments concerning the anatomical differences between pigs and humans, as mentioned in our study limitations. However, the pig model is much more representative of the human anatomy, when compared with canines with a smaller torso, as used in the recently published paper by Roguin *et al.*[2] In our study, the pacemaker leads were implemented with loops comparable with those seen in the humans. Therefore, we do not expect any systematic underestimation of the heating problem. Nevertheless, we agree that special lead configurations may result in higher heating effects. In addition, other positions in the bore may result in higher temperatures as shown in *Figure 2* in our paper.

Our paper does not serve the purpose of an overall recommendation for safe MRI procedures in pacemaker recipients, but to show the realistic temperature excursion *in vivo* to allow interpretation by physiologic accepted temperature limits used by safety requirements. We fully agree with Dr Vahlhaus that this study

and the editorial should not be interpreted as a recommendation for clinicians to perform MRI in pacemaker patients. The diagnostic need for an MRI has to be evaluated individually for each patient, and if there is an urgent necessity and in the absence of an alternative imaging modality, MRI may be considered with the precautions and follow-up measures as recommended by Dr Vahlhaus, in accordance with our paper.

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